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Watkins et al.

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(54) **ELECTRIC VEHICLE CLUSTERED CHARGE DISTRIBUTION AND PRIORITIZATION METHOD, SYSTEM, AND APPARATUS**

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G05D 5/00 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ***G06F 1/28*** (2013.01); ***B60L 11/1816*** (2013.01); ***B60L 11/1824*** (2013.01);

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(58) **Field of Classification Search**
CPC B60L 11/1844; B60L 11/1816; B60L 11/1824; B60L 11/1846; B60L 2270/32; G06F 1/28; G06F 1/26; G06Q 50/06;G07F 15/005; Y02E 60/721; Y02T 10/7291; Y02T 90/169; Y02T 90/128; Y02T 90/14; Y02T 90/121; Y04S 30/14; Y04S 10/12

(Continued)

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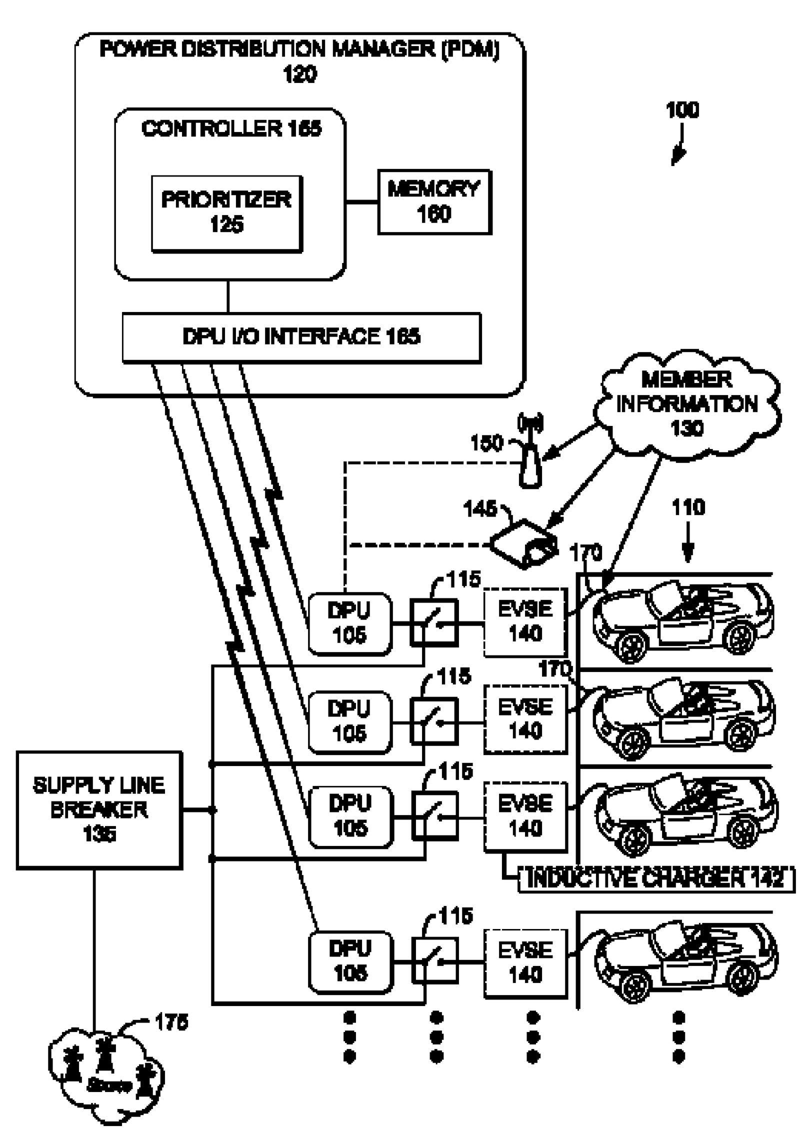
(57) **ABSTRACT**

A method, system, and apparatus include a clustered charge distribution and prioritized charge distribution system for electric vehicles (EVs). Distributed processing units (DPUs) receive member information about an EV or EV user. A power distribution manager (PDM) is coupled to each of the DPUs. The PDM includes a prioritizer. The prioritizer determines a prioritization for charging the EVs based on the member information received by each of the DPUs. Also disclosed is a method for providing clustered charge distribution and charge prioritization for electric vehicles. The method includes sensing whether power is requested by any one of a plurality of EVs within a cluster, generating individual EV-specific information for the EVs using the DPUs, transmitting the EV-specific information to the PDM, and selecting and applying a prioritization algorithm based at least in part on the transmitted information.

15 Claims, 7 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 61/479,728, filed on Apr. 27, 2011.

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G06F 1/28	(2006.01)
G06F 1/26	(2006.01)
G06Q 50/06	(2012.01)
G07F 15/00	(2006.01)
B60L 11/18	(2006.01)
H02J 3/14	(2006.01)

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CPC ***B60L 11/1844*** (2013.01); ***B60L 11/1846*** (2013.01); ***G06F 1/26*** (2013.01); ***G06Q 50/06*** (2013.01); ***G07F 15/005*** (2013.01); *B60L 2230/40* (2013.01); *B60L 2240/72* (2013.01); *B60L 2240/80* (2013.01); *B60L 2260/58* (2013.01); *B60L 2270/32* (2013.01); *H02J 3/14* (2013.01); *Y02E 60/721* (2013.01); *Y02T 10/7005* (2013.01); *Y02T 10/7088* (2013.01); *Y02T 10/7291* (2013.01); *Y02T 90/121* (2013.01); *Y02T 90/128* (2013.01); *Y02T 90/14* (2013.01); *Y02T 90/163* (2013.01); *Y02T 90/169* (2013.01); *Y04S 10/126* (2013.01); *Y04S 30/14* (2013.01)

(58) **Field of Classification Search**
USPC 700/292–298
See application file for complete search history.

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FIG. 1

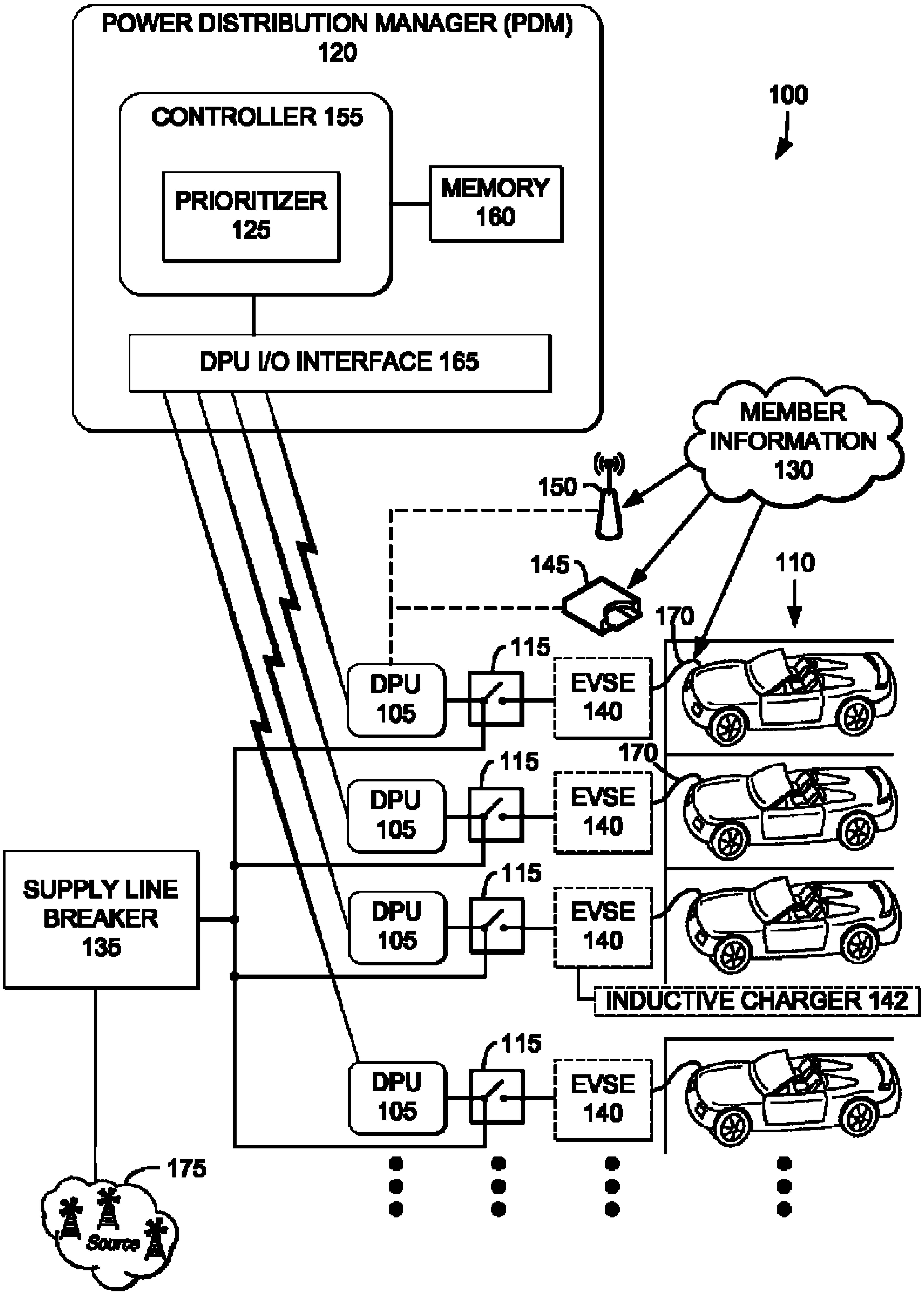

POWER DISTRIBUTION MANAGER (PDM) 120
CONTROLLER 155
PRIORITIZER 125
MEMORY 160
DPU I/O INTERFACE 165
100
MEMBER INFORMATION 130
150
145
110
170
115
DPU 105
EVSE 140
SUPPLY LINE BREAKER 135
INDUCTIVE CHARGER 142
175
Source

FIG. 2

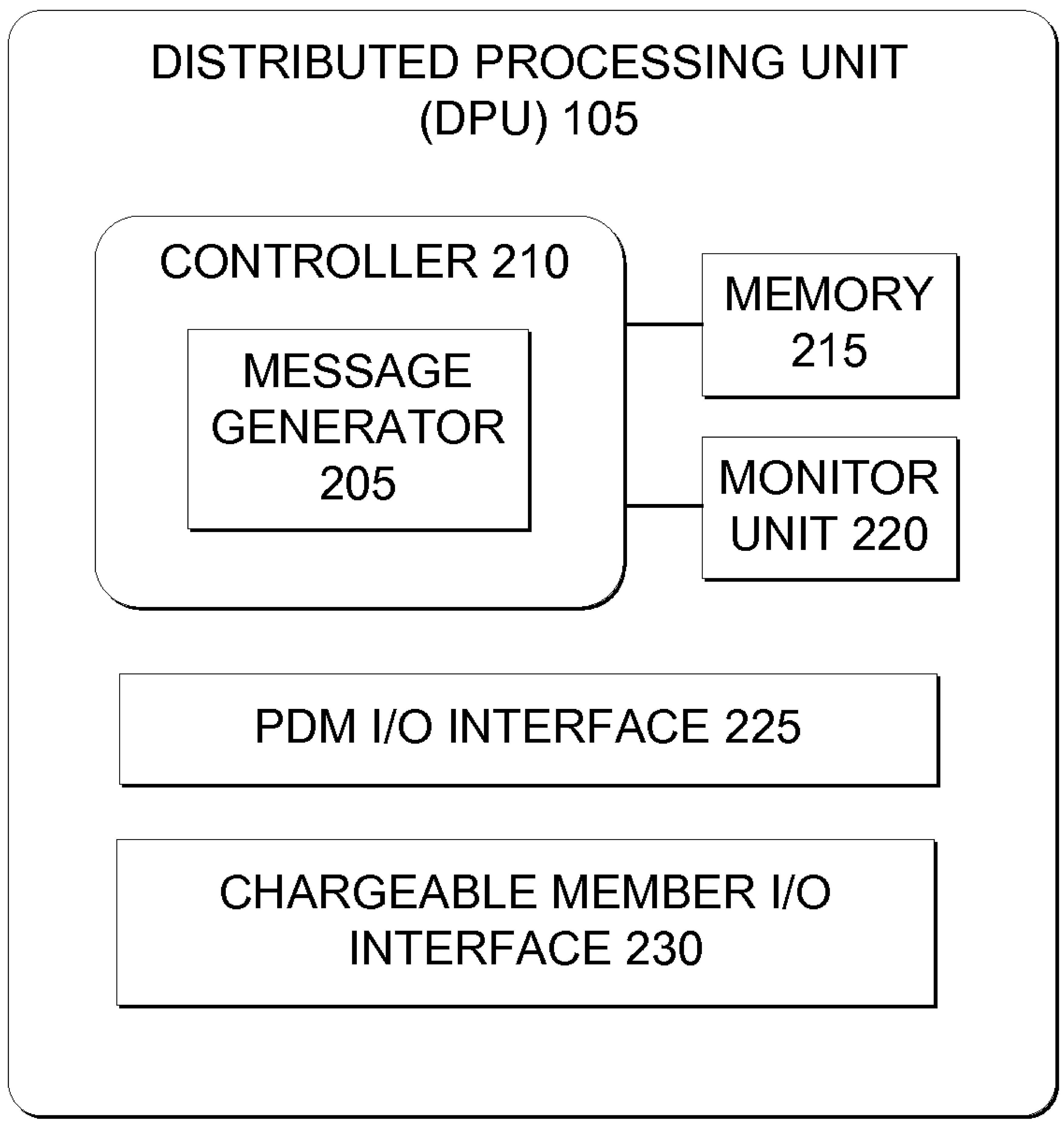

DISTRIBUTED PROCESSING UNIT (DPU) 105
CONTROLLER 210
MESSAGE GENERATOR 205
MEMORY 215
MONITOR UNIT 220
PDM I/O INTERFACE 225
CHARGEABLE MEMBER I/O INTERFACE 230

FIG. 3

300

POWER PORT ID 320	BATTERY CHARGING CAPACITY 325	BATTERY RATING 330	TIME LEFT 335	REALTIME POWER 340	VIP 350
1	100 kWHr	10 A·h	1 MIN	1100 WATTS	YES
2	30 kWHr	100 A·h	10 MIN	1000 WATTS	NO
3	50 kWHr	50 A·h	50 MIN	50 WATTS	NO
4	75 kWHr	25 A·h	72 MIN	750 WATTS	YES

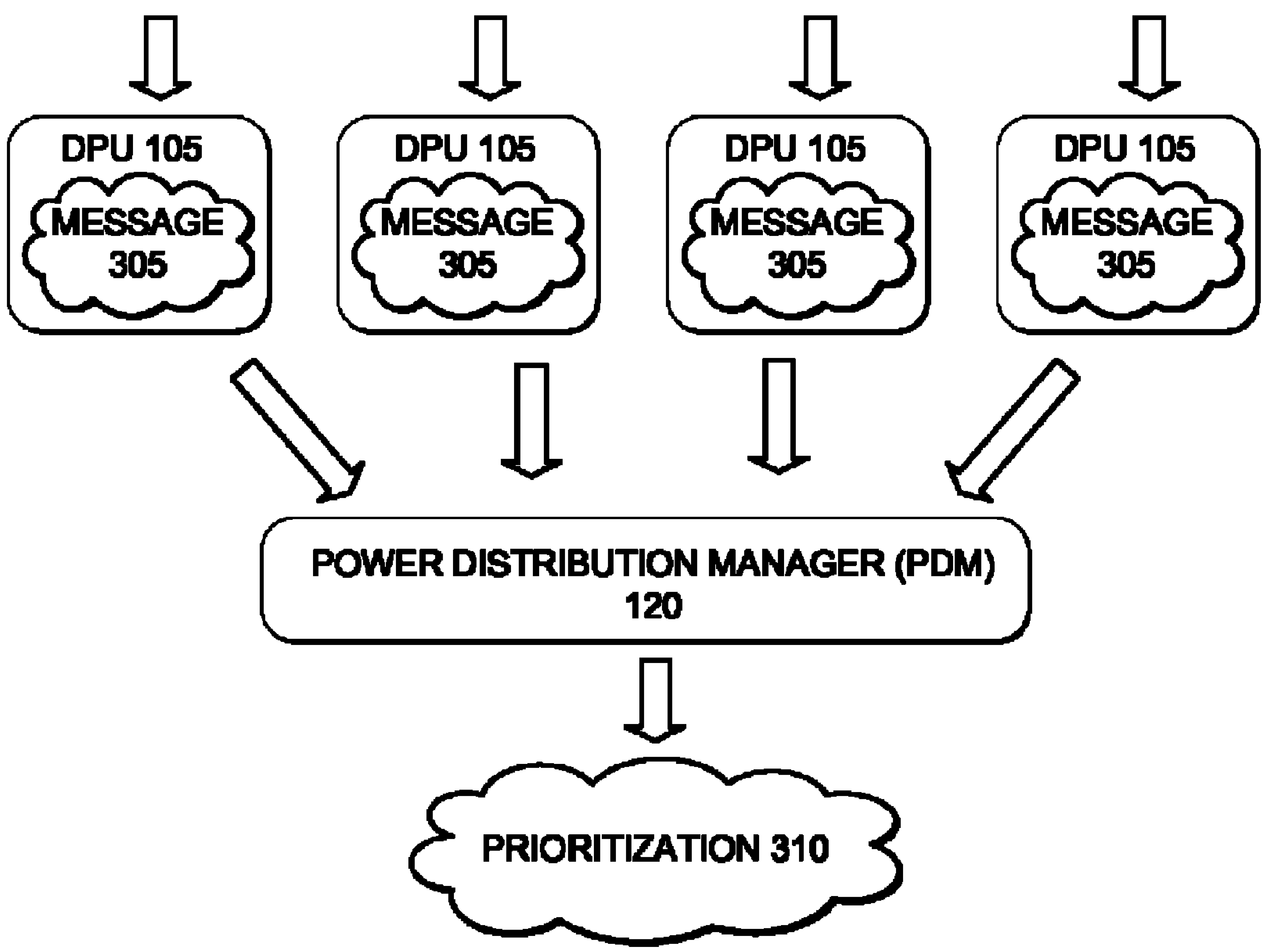


FIG. 4

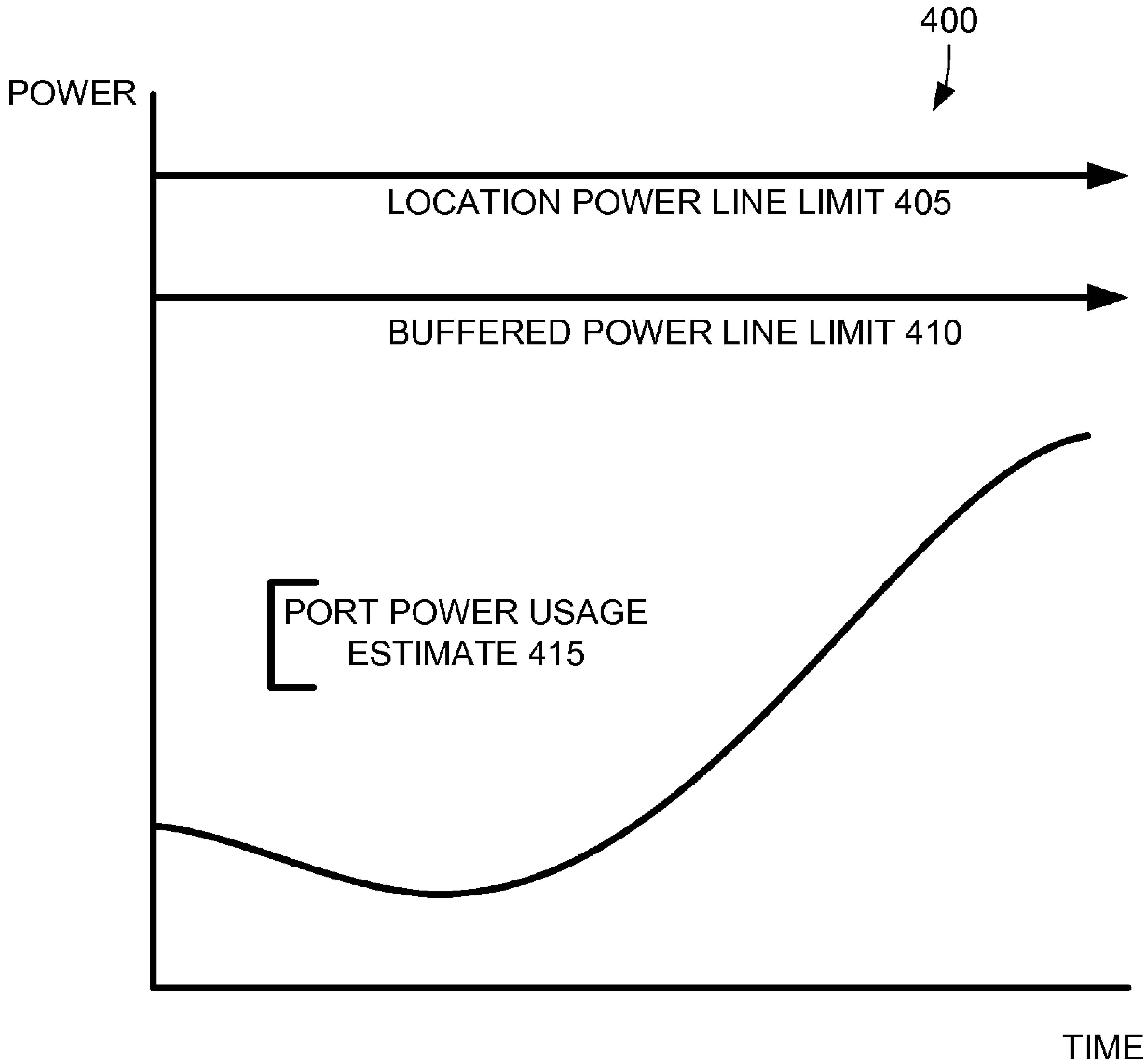

400
POWER
LOCATION POWER LINE LIMIT 405
BUFFERED POWER LINE LIMIT 410
PORT POWER USAGE
ESTIMATE 415
TIME

FIG. 5

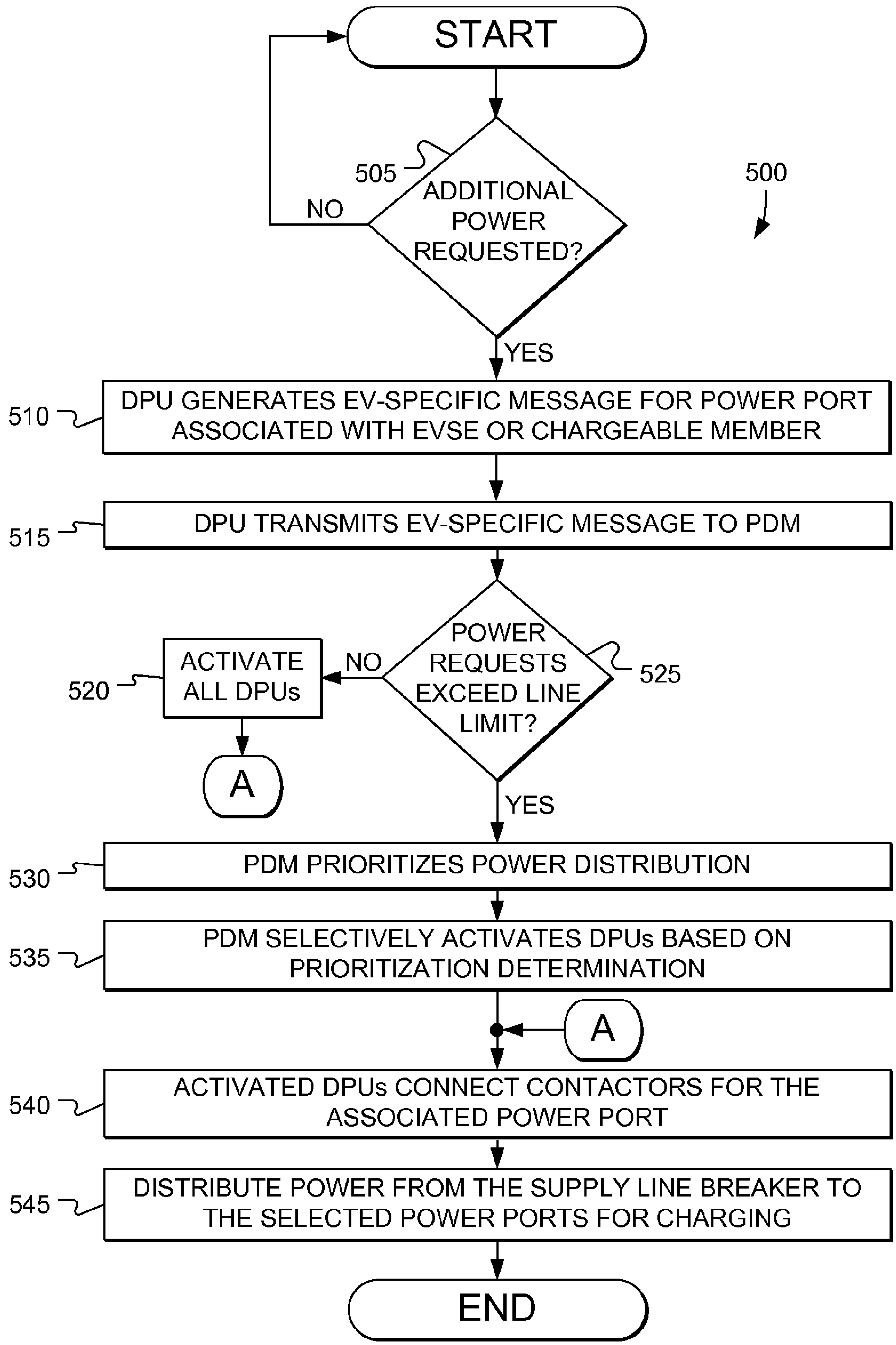

START
505
ADDITIONAL POWER REQUESTED?
NO
YES
500
510
DPU GENERATES EV-SPECIFIC MESSAGE FOR POWER PORT ASSOCIATED WITH EVSE OR CHARGEABLE MEMBER
515
DPU TRANSMITS EV-SPECIFIC MESSAGE TO PDM
520
ACTIVATE ALL DPUs
NO
POWER REQUESTS EXCEED LINE LIMIT?
525
A
YES
530
PDM PRIORITIZES POWER DISTRIBUTION
535
PDM SELECTIVELY ACTIVATES DPUs BASED ON PRIORITIZATION DETERMINATION
A
540
ACTIVATED DPUs CONNECT CONTACTORS FOR THE ASSOCIATED POWER PORT
545
DISTRIBUTE POWER FROM THE SUPPLY LINE BREAKER TO THE SELECTED POWER PORTS FOR CHARGING
END

FIG. 6A

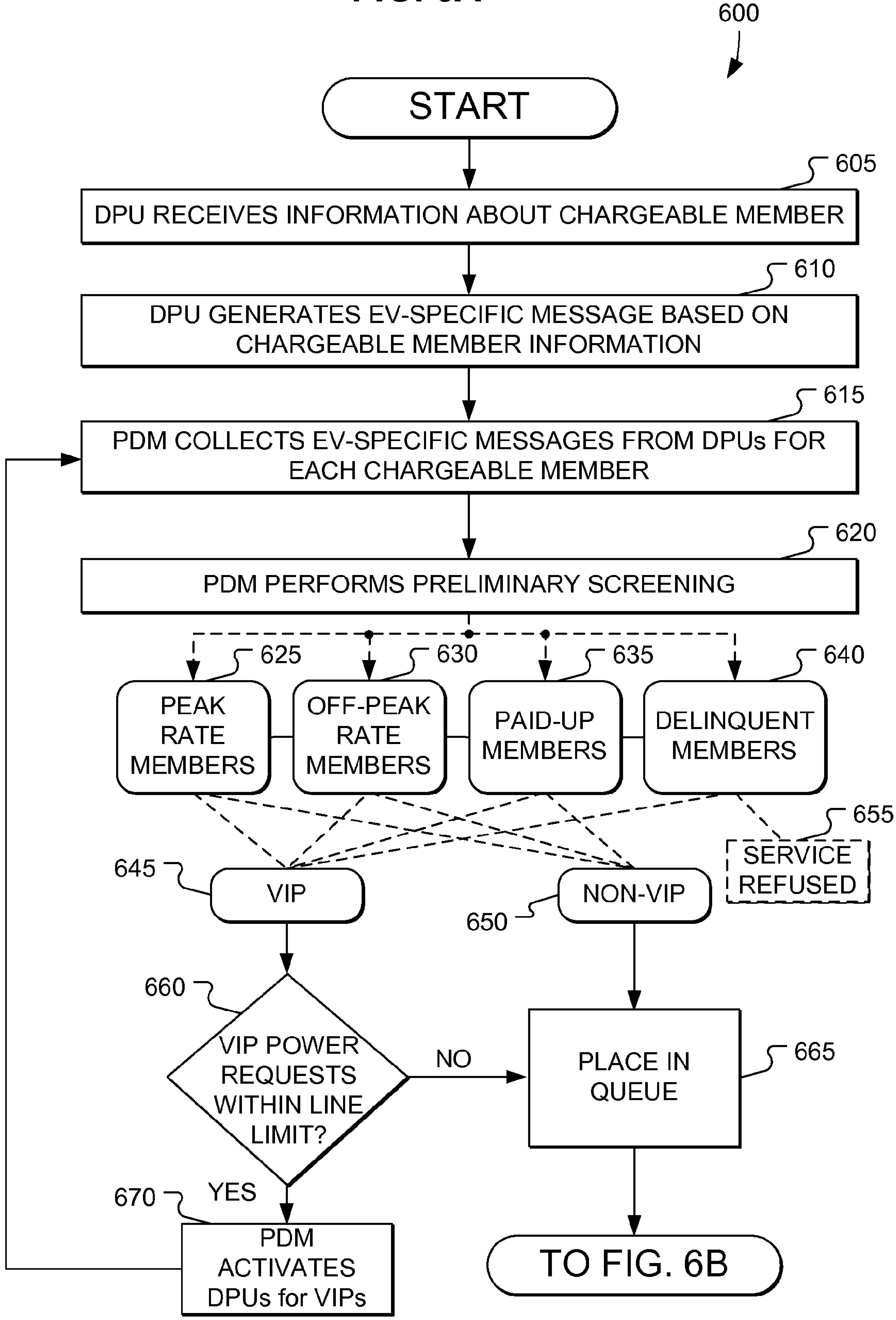
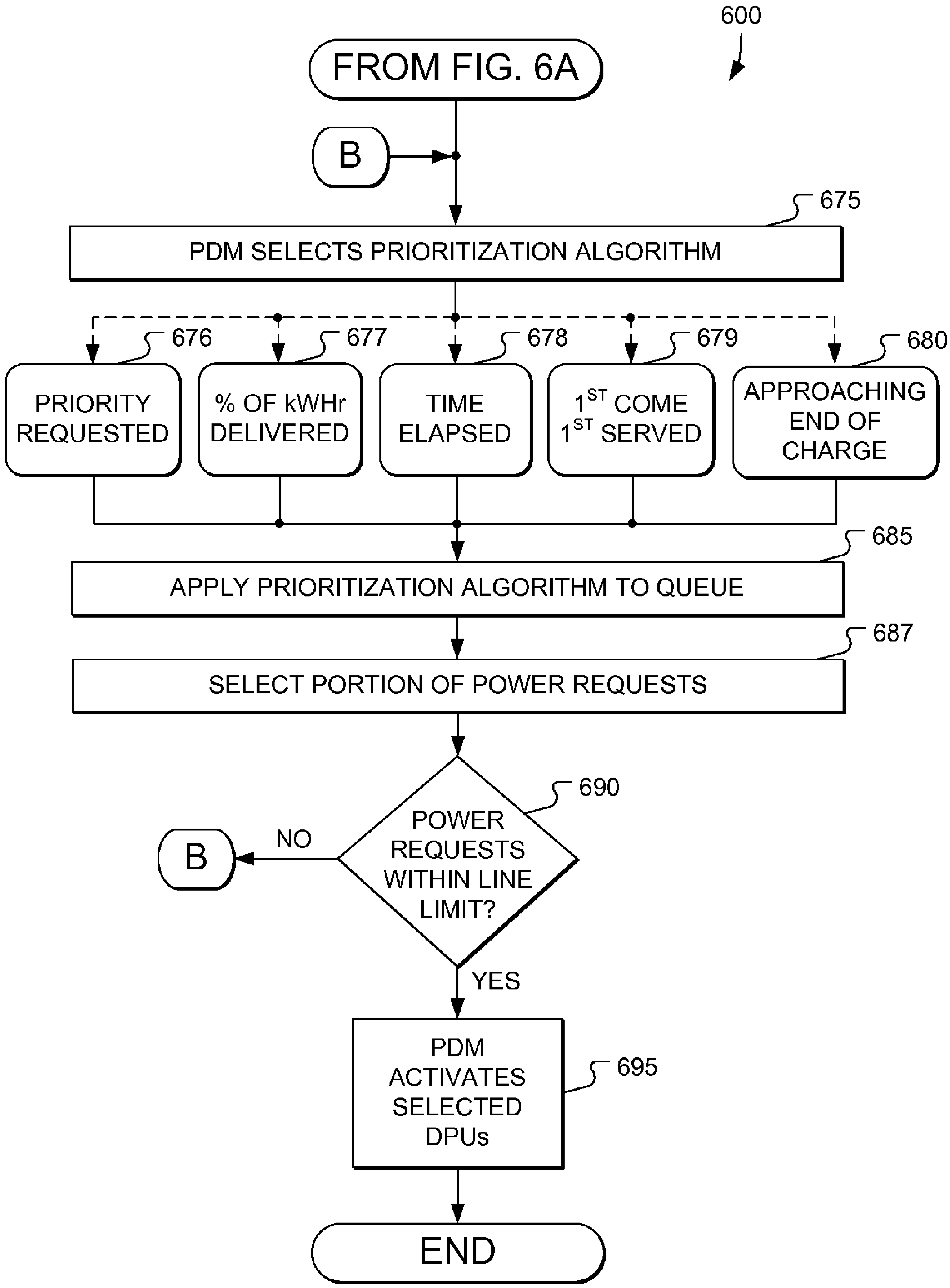

600
START
605
DPU RECEIVES INFORMATION ABOUT CHARGEABLE MEMBER
610
DPU GENERATES EV-SPECIFIC MESSAGE BASED ON CHARGEABLE MEMBER INFORMATION
615
PDM COLLECTS EV-SPECIFIC MESSAGES FROM DPUs FOR EACH CHARGEABLE MEMBER
620
PDM PERFORMS PRELIMINARY SCREENING
625
PEAK RATE MEMBERS
630
OFF-PEAK RATE MEMBERS
635
PAID-UP MEMBERS
640
DELINQUENT MEMBERS
655
SERVICE REFUSED
645
VIP
650
NON-VIP
660
VIP POWER REQUESTS WITHIN LINE LIMIT?
NO
PLACE IN QUEUE
665
YES
670
PDM ACTIVATES DPUs for VIPs
TO FIG. 6B

FIG. 6B


600
FROM FIG. 6A
B
675
PDM SELECTS PRIORITIZATION ALGORITHM
676
677
678
679
680
PRIORITY REQUESTED
% OF kWHr DELIVERED
TIME ELAPSED
1ST COME 1ST SERVED
APPROACHING END OF CHARGE
685
APPLY PRIORITIZATION ALGORITHM TO QUEUE
687
SELECT PORTION OF POWER REQUESTS
690
POWER REQUESTS WITHIN LINE LIMIT?
NO
B
YES
PDM ACTIVATES SELECTED DPUs
695
END

ELECTRIC VEHICLE CLUSTERED CHARGE DISTRIBUTION AND PRIORITIZATION METHOD, SYSTEM, AND APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a divisional of U.S. patent application Ser. No. 13/111,798, filed May 19, 2011, which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/479,728, filed Apr. 27, 2011, all of which are incorporated by reference herein.

TECHNICAL FIELD

This disclosure relates to electric vehicles, and, more particularly, to an apparatus, system, and method for clustered charge distribution and prioritization of charging of electric vehicles.

BACKGROUND

Electric Vehicles (EVs) need to be periodically recharged. This is done by connecting the EV to a charger, which receives its power from an electrical supply line. Plug-in hybrid vehicles also need to be recharged to take advantage of the lower energy costs associated with the established electrical infrastructure. As the adoption rate for these kinds of vehicles (collectively referred to herein as EVs) increases across the globe, users of EVs will have increasing needs for connecting to chargers. The power consumption characteristics of EV chargers are such that when an EV is initially being charged, the EV charger draws substantial power. Conversely, when no EV is connected to the charger, or when an EV is connected but has a "nearly full" charge or a "full" charge, very little or no power is needed by the charger.

The proportion of time the charger is drawing power and charging an EV is, in all cases, less than 100%, and in some cases, can be very low at just a few percent. While chargers can automatically switch off the charging of an EV when the EV is fully charged, the electrical supply line and other location-specific infrastructure are rated to support a generally fixed amount of power (or other related measure such as current), which limits the number of chargers, even if the chargers are not fully being utilized. The requirements of the National Electrical Code (NEC) dictate system design. Systems are designed where all load devices associated with an electrical supply line are simultaneously switched on and all are drawing power at the same time. In other words, designers of such electrical systems plan for a worse-case scenario to ensure that safety conditions and standards are satisfied.

It is conceivable that as EVs are more widely embraced by society at large, multiple chargers will be clustered in a single location, such as an apartment complex or a parking garage. If multiple chargers were to be clustered to meet such charging needs using conventional techniques, the electrical infrastructure required to support such a cluster would be cost prohibitive for the owner of the location in which the cluster is to be installed (e.g., such as the apartment complex or parking garage) because of the large up-front infrastructure investment.

Employing existing technology while maintaining compliance with the NEC limits the size of the cluster to the number of chargers that will draw the maximum line current when all are switched on simultaneously. This, in turn, limits the number of chargers deployable using the existing electrical infrastructure, even though the line load will only infrequently be fully exercised. If more chargers are desired, additional electrical infrastructure must be built out at additional cost and delay, which would impede the acceptance and ramp of EVs into the marketplace.

Moreover, if multiple chargers were carelessly connected to a single electrical supply line, the power demands on the electrical supply line would, in many cases, exceed the maximum line current of the electrical supply line, or otherwise violate safety limits of a supply line breaker associated with the electrical supply line. Such an approach could lead to personal injuries, electrical fires, or other tragedies. Thus, creating such clusters of chargers can be dangerous if done improperly, and is otherwise expensive because it usually means that additional infrastructure must be purchased and installed, including additional supply lines, supply line breakers, safety switches, and the like. This inevitably deters the wider adoption of EVs.

These are only a few of the challenges presented by conventional approaches, which are impeding the wider adoption of electric vehicle technologies, and ultimately hurting efforts for energy independence and environmental responsibility.

Accordingly, a need remains for an improved apparatus, system and method for distributing charges to EVs in a cluster environment. In addition, a need remains for prioritization algorithms for charging the electric vehicles in the cluster environment. Embodiments of the invention address these and other limitations in the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an electric vehicle clustered charge distribution system including various components and information related to charging multiple electric vehicles, and prioritizing the charging of multiple electric vehicles, according to an example embodiment of the present invention.

FIG. **2** illustrates a distributed processing unit component of the system illustrated in FIG. **1**.

FIG. **3** illustrates a table of information about power ports and electric vehicle members of the system illustrated in FIG. **1**, including the assembly of EV-specific information by a power distribution manager and the prioritization thereof, according to example embodiments of the invention.

FIG. **4** illustrates a graph of power versus time, including a location power line limit and a buffered power line limit, according to example embodiments of the invention.

FIG. **5** illustrates a flow diagram including techniques for gathering EV-specific information from distributed processing units and prioritizing power distribution using a power distribution manager, according to example embodiments of the invention.

FIGS. **6A-6B** illustrate a flow diagram including techniques for distributing charges in a clustered charge environment to a group of electric vehicles, including the prioritization of charging of the group of electric vehicles, according to example embodiments of the invention.

The foregoing and other features of the invention will become more readily apparent from the following detailed description, which proceeds with reference to the accompanying drawings.

DETAILED DESCRIPTION

FIG. **1** illustrates an electric vehicle clustered charge distribution system **100**. The system **100** includes a variety of components and information related to simultaneously charging multiple electric vehicles **110**. While often referred to herein as "electric vehicles" or "EVs," such vehicles can include plug-in hybrid vehicles, pure electric vehicles, or any one of a variety of vehicles that operate or move using at least some electricity.

The system **100** includes, for example, multiple distributed processing units **105**. Each distributed processing unit **105**, or DPU, can receive member information **130** about a chargeable member such as EV **110** or a user of the EV **110**. The term "member information" can refer to information specific to the EV **110** itself, such as battery capacity or rating, real time power usage, charging time left, or the like. Alternatively, or in addition to, the term "member information" can refer to characteristics or attributes of a user of the EV **110**, such as whether the user is a paid-up member of an organization or group, whether the user is designated a peak-rate member eligible for drawing charges during peak-rate times, whether the user is a very important person (VIP) having special priority consideration or other privileges, among other possibilities as further described below.

The DPUs **105** are coupled to a power distribution manager **120**, referred to herein as PDM **120**. The DPUs can be wirelessly coupled to the PDM **120** or connected using a conductor or wire. In some embodiments, particularly for locations having multiple parking levels such as a multistory parking garage, one or more DPUs **105** can be situated on each parking level and wirelessly coupled to the PDM **120**, which can be situated on a different parking level or a place remote from the parking levels. In some embodiments, particularly for a single level parking location such as some apartment complexes, the DPUs **105** can be connected to the PDM **120** using a conductor or wired connection.

The PDM **120** includes a controller **155** having a prioritizer **125**. The controller **155** can include, for example, a processor and/or software or firmware for controlling the DPUs **105**. The prioritizer **125** determines a prioritization for charging the electric vehicles **110** based on the member information **130** received by each of the DPUs **105**, as further described in detail below. The PDM **120** can also include a memory **160** for storing information about the EVs **110**, the member information **130**, prioritization algorithms determined by the prioritizer **125**, and the like. The memory can be any suitable non-volatile or volatile memory device or other similar storage device. The PDM **120** also includes an input/output interface **165** for communicating with each of the DPUs **105**.

An input device, such as a wireless device **150** and/or a card reader **145**, can be coupled to each of the DPUs **105**. The wireless device **150** can wirelessly receive the member information **130**. The card reader **145** can receive the member information **130** from a card that is readable by the card reader **145**. It should be understood that other types of input devices can be used, such as a push button (not shown) or key pad (not shown). The input device can be located remotely from the DPU **105**, remotely from the PDM **120**, proximate or attached to the DPU **105**, proximate or attached to the PDM **120**, proximate or attached to a charger for the EV **110** or other electric vehicle supply equipment, and/or proximate to a parking space for the EV **110**. Each input device can receive the member information **130** for a corresponding EV or EV user.

In some embodiments, a single input device (e.g., **150** or **145**) can be used to receive the member information **130** from one or more EVs or EV users. In cases where a single input device is used, the single input device can be coupled either to one of the DPUs **105** or directly to the PDM **120**.

In some embodiments, the member information **130** is transmitted over the charging cord **170** itself, through an electric vehicle supply equipment unit **140**, and then to the DPU **105** and/or PDM **120**. In some embodiments, particularly for systems having multiple parking levels such as a multistory parking garage, one or more input devices such as **150** and/or **145** can be situated on each parking level. The member information **130** is ultimately received by the PDM **120**, regardless of the number and placement of the input devices **150** and/or **145**, and then used by the prioritizer **125** to determine a prioritization of charge distribution.

Electrical contactors **115** are coupled to and controlled by each of the DPUs **105**. One or more of the DPUs **105** are selectively activated or signaled by the PDM **120** to begin charging. In some embodiments, a subset of the DPUs **105** is activated by the PDM **120** based on the prioritization for charging the EVs **110**. In response to such activation or signaling by the PDM **120**, the selected DPUs cause the associated electrical contactor **115** to permit charging of the associated EV **110**. Electricity is then permitted to flow from the source **175** to the associated EV **110** through the supply line breaker **135**.

The system **100** can optionally include electric vehicle supply equipment (EVSE) units **140**, sometimes referred to as chargers. EVSE units **140** can supply electric charging at higher voltages and currents than are available from a typical electric socket outlet. Each of the EVSE units **140** can be coupled to a corresponding one of the electrical contactors **115**. A charging cord **170** can be coupled to each of the EVSE units **140**. Each of the charging cords **170** can be coupled to one of the EVs **110**. Alternatively, an inductive charger **142** can be coupled to or otherwise associated with one or more of the EVSE units and can inductively charge the EV **110**.

It should be understood that EVSE units **140** need not be used, and the charging cord **170** and/or the inductive charger **142** can be coupled directly to the electric contactor **115** and/or directly to the DPU **105**. The DPUs **105** are configured to control the amount of charge transferred between the supply line breaker **135** and the EVSE units **140**, and/or between the supply line breaker **135** and the EVs **110**. The DPUs **105** are also configured to control when charge is transferred between the supply line breaker **135** and the EVSE units **140**, and/or between the supply line breaker **135** and the EVs **110**.

FIG. **2** illustrates a distributed processing unit (DPU) **105** component of the system illustrated in FIG. **1**. FIG. **3** illustrates table **300** of information about power ports and electric vehicle members of the system illustrated in FIG. **1**, including the assembly of EV-specific information by a power distribution manager and the prioritization thereof, according to example embodiments of the invention. Reference is now made to FIGS. **2** and **3**.

The DPU **105** includes a controller **210** to control a charge flow between the supply line breaker **135** and the EVs **110** responsive to the PDM **120**. A message generator **205** is associated with or otherwise included in each of the DPUs **105**. The message generator **205** generates individual EV-specific messages **305** based on the member information **130** received about the EVs **110** and/or EV users. As mentioned above, the DPU **105** can receive the member information **130** from the EV **110** or EV user through, for example, the wireless device **150**, the card reader **145**, the inductive charger **142**, and/or through the power cord **170**. After receiving the member information **130**, the message generator **205** generates an individual message including a collection of data about the corresponding EV **110** and/or EV user.

The member information **130** can be transmitted a single time or periodically (e.g., during charging of the EV **110**) to the DPU **105**. The member information **130** can include information about the EV **110** such as battery charging capacity **325** of one or more batteries associated with the EV **110**, battery rating **330** for one or more batteries associated with the EV **110**, real time power usage **340** of one or more batteries associated with the EV **110**, time left **335** for fully charging one or more batteries associated with the EV **110**, the power port ID **320** to which the power cord **170** of the EV **110** is attached, the arrival or attachment time of the power cord **170** to the power port ID **320**, the arrival time of the EV **110** as sensed by the inductive charger **142**, the percentage (%) of kWHr delivered so far to the EV **110**, the time elapsed since a particular EV **110** began to receive a charge, whether the EV **110** is approaching the end of its charge, an amount of power requested by the EV **110**, among other suitable information related to the EV **110**.

The member information **130** can also include information about a user of the EV **110** such as whether the user is a paid-up member or a delinquent member of an organization or group, whether the user is designated a peak-rate member eligible for drawing charges during electricity peak-rate times or an off-peak rate member eligible for drawing charges only during off-peak rate times, whether the user is a very important person (VIP) **350** having special priority consideration or other privileges, whether a particular priority is requested by the user, whether a particular power request is submitted by the user, among other suitable characteristics or attributes of the user of the EV **110**.

The DPUs **105** receive the member information **130** associated with one or more EVs **110** or one or more users of the EVs **110**. The DPUs **105** can generate individual EV-specific messages **305** using the message generator **205**. The DPUs **105** can also include a monitor unit **220** to monitor requests for additional power received from the EVs **110** and/or the EVSEs **140**. The requests for power can be monitored directly relative to the power being drawn over the power cord **170** or another connection between the EVSEs **140** and the DPUs **105**. In other words, the requests for power can be recognized by the DPUs **105** by measuring the input and/or output power levels.

The monitor unit **220** can monitor the requests for power indirectly such as through a separate communication interface between the EV **110** and the DPU **105** (not shown), and/or a separate communication interface between the EVSE **104** and the DPU (not shown). The monitor unit **220** can also monitor for information similar to the member information **130** discussed above, either directly or indirectly relative to the EV **110** and/or the EVSE **140** using the separate communication interface.

The message generator **205** can generate the individual EV-specific messages **305** based at least on the member information **130** and/or the information gathered by the monitor unit **220**. After producing the individual messages **305**, the DPUs **115** transmit the individual messages **305** to the PDM **120** for further processing. Each individual EV-specific message **305** includes a collection of data that is specific to the EV **110** and/or the user of the EV **110**, which taken together, provides useful information to the PDM **120** for selecting a particular prioritization algorithm and prioritizing the charging of the EVs **110** in accordance with the algorithm.

Each DPU **105** can also include a memory **215** coupled to the controller **210**. The memory **215** can store a prioritization **310** determined by the prioritizer **125** of the PDM **120**. The memory can be any suitable non-volatile or volatile memory device or other similar storage device. Each DPU **105** can include a first input/output interface **225** for communicating with the PDM **120** and a second input/output interface **230** for communicating with the input device such as the wireless input device **150** and/or the card reader **145**. The second input/output interface **230** can receive the member information **130**. The monitor unit **220** can also receive information about power requests, etc., using the input/output interface **230**.

The PDM **120** receives the individual EV-specific messages **305** from one or more of the DPUs **105**. The prioritizer **125** of the PDM **120** determines the prioritization **310** based on the collection of information contained within the individual messages **305**, as described in further detail below.

FIG. **4** illustrates a graph **400** of power versus time, including a location power line limit **405** and a buffered power line limit **410**, according to example embodiments of the invention. Generally, a particular location has associated therewith a power line limit **405**, or in other words, the total amount of power that can be drawn at a given time over the power line that provides power to the particular location. It should be understood that the line limit **405** can also be represented by other values including current, voltage, and/or time. The location will have other power equipment suitable for use with the power line, such as one or more supply line breakers **135** (of FIG. **1**). The one or more supply line breakers **135** can have the power line limit **405** associated therewith so that if the power line limit **405** is exceeded in any way, the supply line breakers **135** can disconnect or otherwise interfere with the flow of charge so that dangerous electrical situations or accidents are avoided.

The PDM **120** can calculate or otherwise determine a buffered power line limit **410**. Alternatively, the PDM **120** can receive from an operator of the system **100** an appropriate buffered power line limit **410**. The buffered power line limit **410** is less than the location power line limit **405** so that a safety margin is built into the system **100**, which further reduces the chances of ever exceeding the location power line limit **405**, and also increases the safety of the system **100**.

In some embodiments of the present invention, the location power line limit **405** and/or the buffered power line limit **410** are less than the total power that can be drawn by the EVs **110** during charging. In other words, in the absence of the prioritization techniques as disclosed herein, both the location power line limit **405** and the buffered power line limit **410** would be exceeded because the system **100** is designed to charge significantly more EVs **110** than would otherwise be permitted using conventional technologies.

Using the embodiment of the invention disclosed herein, however, neither the location power line limit **405** nor the buffered power line limit **410** are exceeded, even though significantly more EVs **110** are attached to the system **100** and simultaneously requesting power than would otherwise be permitted. The PDM **120** and/or the individual DPUs **105** can determine a power port usage estimate **415** based on information included within the individual messages **305**. Knowing the power port usage estimate **415** allows the PDM **120** to accurately prioritize the charging of the EVs **110** while satisfying NEC standards. In other words, the prioritizer **125** of the PDM **120** prioritizes the charging of the EVs **110** so that the location power line limit **405** and/or the buffered power line limit **410** are not exceeded.

FIG. **5** illustrates a flow diagram **500** including techniques for gathering EV-specific information **305** from DPUs **105** and prioritizing power distribution using the PDM **120**, according to example embodiments of the invention.

The technique begins at **505** by sensing whether any power, or any additional power, is requested by any one of a plurality of N electric vehicles **110** with a cluster of vehicles **110**. At **510**, each DPU **105** generates an individual EV-specific message **305** for a particular power port associated with the EVSE **104** and/or the EV **110**. For instance, a first EV-specific message **305** can be generated, using a first DPU **105**, for a first EV **110**. The first message can be associated with a first power port connected to the first EV **110**. Similarly, a second EV-specific message **305** can be generated, using a second DPU **105**, for a second EV **110**. The second message can be associated with a second power port connected to the second EV **110**. Moreover, an Nth EV-specific message **305** can be generated, using an Nth DPU **105**, for an Nth EV **110**. The Nth message can be associated with an Nth power port connected to the Nth EV **110**.

At **515**, the first, second, and Nth messages **305** are transmitted from the first, second, and Nth DPU **105**, respectively, to the PDM **120**. At **525**, the PDM **120** can determine whether power requested by the first, second, and Nth EVs **110** exceeds a location power line limit **405** and/or a buffered power line limit **410**. If NO, meaning all of the EVs **110** connected to the system **100** would not exceed the **405** and/or **410** line limit, then the flow proceeds to **520** where all of the DPUs **150** are activated so that all of the EVs **110** desiring a charge receives one. In other words, the first, second, and Nth DPUs **105** are activated so that all of the first, second, and Nth EVs **110** receive a charge. The flow then goes through bubble A, thereby skipping the prioritization steps.

Otherwise, if YES, meaning the power requested exceeds the line limit **405** and/or **410**, then the flow proceeds to **530**, where the PDM **120** prioritizes the power distribution. More specifically, the PDM **120** compares the collection of data within the first, second, and Nth messages **305** and determines a prioritization **310** based on the collected data. At **535**, the PDM **120** selectively activates a subset of the first, second, and Nth DPUs **105** based on the prioritization **310**.

The flow then proceeds to **540**, where the activated DPUs **105** cause the electrical contactors **115** associated with the activated DPUs **105** to connect, thereby causing a charge to flow. As a result, at **545**, power is distributed from the supply line breaker **135** to the subset of the first, second, and Nth EVs **110** based on the prioritization **310**.

FIGS. **6A**-**6B** illustrate a flow diagram **600** including techniques for distributing charges in a clustered charge environment to a group of EVs **110**, including the prioritization of charging of the group of EVs **110**, according to example embodiments of the invention. Reference is now made to FIGS. **6**A and **6**B.

In some embodiments, techniques include providing clustered charge distribution and charge prioritization for EVs **110**. Specifically, for this embodiment, the process begins at **605** where the DPU **105** receives information about a chargeable member such as the EV **110**. The information can include, for example, the member information **130** described above. In some embodiments, the member information **130** about the EVs **110** is received at a plurality of DPUs **105**.

At **610**, each DPU **105** generates an EV-specific message **305** based at least on the member information **130** received for each EV **110**. The PDM **120** then collects, at **615**, the message **305** from each of the DPUs **105**. After the individual messages **305** have been collected, the PDM **120** performs a preliminary screening of the EVs **110** and/or users of the EVs **110** based on the collection of data within the messages **305**.

The preliminary screening **620** can include, for example, determining that a user of the EV **110** is a delinquent member **640** of a group or organization associated with the system **100**. And if so, such user can be excluded or refused charging service at **655**. If, however, the user is a paid-up member **635**, then charging service is not refused on that basis. When it is determined that a user of the EV **110** is an off-peak rate preference member at **630**, then charging service can be excluded for such a member during peak-rate electricity times. Conversely, when it is determined that a user of the EV **110** is a peak rate preference member, then charging service is not excluded for such a member during peak-rate times.

The preliminary screening **620** can further include separating users by VIP status. For instance, of the remaining users not yet excluded from charging service, the messages **305** associated with the remaining users can be parsed by the PDM **120** to determine whether users of the electric vehicles are VIPs or not, and divided into a VIP group **645** and a non-VIP group **650**. For users of the EVs **110** determined not to be VIPs, any power requests for these non-VIPs can be added to a queue at **665**. Otherwise, for the users of the EVs **110** determined to be VIPs, the aggregate power requests from the VIPs can be checked or otherwise verified to fall within the location power line limit **405** and/or the buffered power line limit **410**.

When it is determined at **660** that the requests from the VIPs are within the location power line limit **405** and/or buffered power line limit **410**, the DPUs **105** associated with the EVs **110** of the VIPs can be activated so that the EVs **110** for the VIPs are charged at **670**, after which the PDM **120** again collects EV-specific information from the DPUs at **615**. Otherwise, when it is determined that the requests from the VIPs are not within the location power line limit **405** and/or the buffered power line limit **410**, at least some or all of the power requests from said VIPs are added to the queue. Indeed, all of the remaining power requests from said VIPs and/or non-VIPs can be added to the queue at **665**.

The flow then proceeds to FIG. **6**B, where the PDM **120** selects a prioritization algorithm at **675**. More specifically, the prioritizer **125** (of FIG. **1**) is configured to determine the prioritization **310** (of FIG. **3**) based on at least one of or all of (a) a priority requested **676** by a user of a particular electric vehicle, (b) a percentage of kWHr **677** delivered so far to a particular EV **110**, (c) time elapsed **678** since a particular EV **110** began to receive a charge, (d) a first come first served order **679** in which a particular EV **110** is given a higher priority based on its start or arrival time, and (e) whether a particular electric vehicle is approaching the end of its charge **680**. Furthermore, the prioritization algorithm can take into account other factors such as parking spot location, i.e., whether a particular parking spot is closest to a door, whether the user is willing to pay a premium rate, and so forth.

Applying the prioritization algorithm to requests in the queue at **685** can include: prioritizing at **676** based on a priority requested by a user, prioritizing at **677** based on a percentage of kWHr delivered so far to a particular EV **110**, prioritizing at **678** based on time elapsed since a particular EV **110** began to receive a charge, prioritizing at **679** based on a first come first served order in which a particular EV **110** is given a higher priority based on its start or arrival time, and prioritizing at **680** based on a whether a particular

EV **110** is approaching the end of its charge. Other suitable factors described herein can be used when applying the prioritization algorithm.

At **687**, a portion of the power requests are selected by the PDM **120** from the queue based on the prioritization algorithm used. The flow then proceeds to **690** where a determination is made whether the selected portion of the power requests is within the location power line limit **405** and/or the buffered location power line limit **410**. If NO, the flow goes through bubble B to **675** where the PDM **120** can select a different prioritization algorithm or revise the prioritization algorithm accordingly. Otherwise, if YES, the flow proceeds to **695** where the PDM **120** selectively activates DPUs **105** associated with the portion of power requests selected as a result of the application of the prioritization algorithm. Thus, a subset of the DPUs **105** can be selectively activated based at least on the preliminary screening and the prioritization algorithm.

Other embodiments may provide for alternate configurations, which carryout similar objectives to the preferred embodiments. These can include, for example, safety features in which the PDM **120** signals one or more DPUs **105** to shut off or otherwise enter a "safe mode" if the PDM **120** detects that the line limits **405** and/or **410** have been exceeded. Moreover, if a predefined amount of time lapses or the DPUs **105** cannot communicate with the PDM **120** for a predefined amount of time, the DPUs **105** can automatically shut off or otherwise enter the safe mode, thereby adding yet another layer of protection and safety.

Embodiments of the present invention manage the power from the supply line to the charger cluster. The system can distribute power to those chargers and/or EVs that require or request it until the line load limits are approached. The system can deny access to other chargers and/or EVs calling for power until one of the currently powered chargers and/or EVs completes its charging task, and shuts down or is otherwise disconnected from the system. The PDM **120** can time slot manage the power according to a time slot algorithm in which each EV **110** receives a charge for a period of time. The length of the period of time can be determined, at least in part, based on the prioritization of the charging as described above.

In some embodiments, the PDM **120** permits charging access to all EVs, but causes the power delivered to each EV to be reduced by a predefined amount so that any given or all chargers do not exceed the line limits. In a further manifestation, the PDM **120** permits charge to flow through all chargers, but instructs the chargers to limit the power they draw such that the total line limits are not exceeded.

The PDM **120** can also cause charging to automatically take place during off-peak times and/or other specially priced power conditions. The clustered charging system, as described herein, can be implemented or otherwise used in private residential environments where multiple EVs are in the same garage and use a common electrical supply line. Alternatively, the system can be deployed in publicly accessible locations such as airport parking lots, public garages, libraries, movie theaters, and the like. The clustered charging system can be used in apartment complexes or parking garage type environments where the electrical supply line might supply a floor or a sector of a floor. Indeed, any place having some finite quantity of power and the desire to charge multiple EVs that would otherwise exceed the power line limits of the location, can benefit by the features and advantages of the embodiments of the present invention. The number of chargers in the cluster and the number of DPUs in the cluster, etc., can be increased and the desired charging power delivered without adding additional electrical supply infrastructure.

Furthermore, embodiments of the invention may include a method by which modularized components provide flexibility across a variety of communication systems and charging infrastructure, and allow users and station owners, apartment complex owners, garage owners, and the like, to implement a clustered charge distribution and charge prioritization system as a relatively discrete system, or alternatively, in combination with other charge station capabilities and EVSEs.

Although the foregoing discussion has focused on particular embodiments, other configurations are contemplated. In particular, even though expressions such as "according to an embodiment of the invention" or the like are used herein, these phrases are meant to generally reference embodiment possibilities, and are not intended to limit the invention to particular embodiment configurations. As used herein, these terms can reference the same or different embodiments that are combinable into other embodiments.

The following discussion is intended to provide a brief, general description of a suitable machine or machines in which certain aspects of the invention can be implemented. Typically, the machine or machines include a system bus to which is attached processors, memory, e.g., random access memory (RAM), read-only memory (ROM), or other state preserving medium, storage devices, a video interface, and input/output interface ports. The machine or machines can be controlled, at least in part, by input from conventional input devices, such as keyboards, mice, etc., as well as by directives received from another machine, interaction with a virtual reality (VR) environment, biometric feedback, or other input signal. As used herein, the term "machine" is intended to broadly encompass a single machine, a virtual machine, or a system of communicatively coupled machines, virtual machines, or devices operating together. Exemplary machines include computing devices such as personal computers, workstations, servers, portable computers, handheld devices, telephones, tablets, etc., as well as transportation devices, such as private or public transportation, e.g., automobiles, trains, cabs, etc.

The machine or machines can include embedded controllers, such as programmable or non-programmable logic devices or arrays, Application Specific Integrated Circuits (ASICs), embedded computers, smart cards, and the like. The machine or machines can utilize one or more connections to one or more remote machines, such as through a network interface, modem, or other communicative coupling. Machines can be interconnected by way of a physical and/or logical network, such as an intranet, the Internet, local area networks, wide area networks, etc. One skilled in the art will appreciated that network communication can utilize various wired and/or wireless short range or long range carriers and protocols, including radio frequency (RF), satellite, microwave, Institute of Electrical and Electronics Engineers (IEEE) 545.11, Bluetooth®, optical, infrared, cable, laser, etc.

Embodiments of the invention can be described by reference to or in conjunction with associated data including functions, procedures, data structures, application programs, etc. which when accessed by a machine results in the machine performing tasks or defining abstract data types or low-level hardware contexts. Associated data can be stored in, for example, the volatile and/or non-volatile memory, e.g., RAM, ROM, etc., or in other storage devices and their associated storage media, including hard-drives, floppydisks, optical storage, tapes, flash memory, memory sticks, digital video disks, biological storage, etc. Associated data can be delivered over transmission environments, including the physical and/or logical network, in the form of packets, serial data, parallel data, propagated signals, etc., and can be used in a compressed or encrypted format. Associated data can be used in a distributed environment, and stored locally and/or remotely for machine access.

Other similar or non-similar modifications can be made without deviating from the intended scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

The invention claimed is:

1. A clustered charge distribution and prioritization system, comprising:

a plurality of distributed processing units, each distributed processing unit configured to receive member information about a chargeable member; and

a power distribution manager coupled to each of the distributed processing units, the power distribution manager including a prioritizer,

wherein the prioritizer is configured to determine a prioritization for charging the chargeable members based on the member information received by each of the distributed processing units;

wherein the chargeable members are electric vehicles, the system further comprising a supply line breaker having a location power line limit associated therewith, the location power line limit being less than the total power that can be drawn by the electric vehicles during charging;

wherein the prioritizer of the power distribution manager is configured to prioritize charging of the electric vehicles so that the location power line limit is not exceeded;

wherein the power distribution manager is configured to selectively activate a subset of the distributed processing units based on the prioritization for charging the electric vehicles;

the system further comprising:

an electrical contactor coupled to each of the distributed processing units; and

a message generator associated with each of the distributed processing units;

wherein:

the message generator is configured to generate individual EV-specific messages based on the member information received about the electric vehicles;

the power distribution manager is configured to receive the individual messages from the distributed processing units;

the prioritizer is configured to determine the prioritization based on the individual messages;

the selectively activated distributed processing units are configured to cause the associated electrical contactor to permit charging of the associated electric vehicle responsive to the power distribution manager; and

the message generator is configured to generate the individual message for each electric vehicle based at least on (a) battery characteristics associated with an electric vehicle, (b) time left for charging an electric vehicle, (c) power requested by an electric vehicle, or (d) peak rate/off-peak rate preference of the user of the electric vehicle.

2. The system of claim **1**, wherein:

the power distribution manager is configured to determine a buffered power line limit;

the prioritizer of the power distribution manager is configured to prioritize charging of the electric vehicles so that the buffered power line limit is not exceeded; and

the buffered power line limit is less than the location power line limit.

3. The system of claim **1**, wherein the distributed processing units are configured to control the amount of charge transferred between the supply line breaker and the electric vehicles.

4. The system of claim **1**, wherein the distributed processing units are configured to control when charge is transferred between the supply line breaker and the electric vehicles.

5. The system of claim **1**, further comprising:

a plurality of electric vehicle supply equipment units, wherein each electric vehicle supply equipment unit is coupled to a corresponding one of the electrical contactors;

a charging cord coupled to each of the electric vehicle supply equipment units, wherein each of the charging cords is configured to be coupled to one of the electric vehicles,

wherein the distributed processing units are configured to control the amount of charge transferred between the supply line breaker and the electric vehicle supply equipment units.

6. The system of claim **1**, wherein each of the plurality of distributed processing units includes:

a controller configured to control a charge flow between the supply line breaker and the electric vehicles responsive to the power distribution manager;

a memory coupled to the controller, wherein the memory is configured to store the prioritization determined by the prioritizer of the power distribution manager;

a monitor unit configured to monitor requests for additional power received from the electric vehicles;

a first input/output interface configured to communicate with the power distribution manager; and

a second input/output interface configured to communicate with at least one of a card reader and a wireless input device,

wherein the second input/output interface is configured to receive the member information, and

wherein the message generator is configured to generate the individual messages based at least on the member information and the monitor unit.

7. The system of claim **1**, further comprising:

an input device coupled to each of the distributed processing units, each input device configured to receive the member information for a corresponding chargeable member.

8. The system of claim **7**, wherein the input device comprises a card reader configured to receive the member information from a card that is readable by the card reader.

9. The system of claim **7**, wherein the input device comprises a wireless input device configured to wirelessly receive the member information.

10. The system of claim **1**, wherein the power distribution manager further includes:

a controller configured to control the plurality of distributed processing units, wherein the controller includes the prioritizer;

a memory coupled to the controller, wherein the memory is configured to store the prioritization determined by the prioritizer; and

an input/output interface configured to communicate with each of the distributed processing units.

11. The system of claim **1**, wherein the prioritizer is configured to determine the prioritization based on at least one of (a) a priority requested by a user of a particular electric vehicle, (b) a percentage of kWHr delivered so far to a particular electric vehicle, (c) time elapsed since a particular electric vehicle began to receive a charge, (d) a first come first served order in which a particular electric vehicle is given a higher priority based on its start or arrival time, and (e) whether a particular electric vehicle is approaching the end of its charge.

12. The system of claim **1**, wherein the prioritizer is configured to determine the prioritization based on all of (a) a priority requested by a user of a particular electric vehicle, (b) a percentage of kWHr delivered so far to a particular electric vehicle, (c) time elapsed since a particular electric vehicle began to receive a charge, (d) a first come first served order in which a particular electric vehicle is given a higher priority based on its start or arrival time, and (e) whether a particular electric vehicle is approaching the end of its charge.

13. The system of claim **1**, further comprising:

a supply line breaker having a location power line limit associated therewith, the location power line limit being less than the total power that can be drawn by the electric vehicles during charging;

wherein the power distribution manager is configured to reduce, by a predefined amount, an amount of power delivered to each EV so that any given or all chargers do not exceed the location power line limit.

14. A clustered charge distribution and prioritization system, comprising:

a plurality of distributed processing units, each distributed processing unit configured to receive member information about a chargeable member; and

a power distribution manager coupled to each of the distributed processing units, the power distribution manager including a prioritizer,

wherein the prioritizer is configured to determine a prioritization for charging the chargeable members based on the member information received by each of the distributed processing units;

wherein the chargeable members are electric vehicles, the system further comprising a supply line breaker having a location power line limit associated therewith, the location power line limit being less than the total power that can be drawn by the electric vehicles during charging;

wherein the prioritizer of the power distribution manager is configured to prioritize charging of the electric vehicles so that the location power line limit is not exceeded;

wherein the power distribution manager is configured to selectively activate a subset of the distributed processing units based on the prioritization for charging the electric vehicles;

the system further comprising:

an electrical contactor coupled to each of the distributed processing units; and

a message generator associated with each of the distributed processing units;

wherein:

the message generator is configured to generate individual EV-specific messages based on the member information received about the electric vehicles;

the power distribution manager is configured to receive the individual messages from the distributed processing units;

the prioritizer is configured to determine the prioritization based on the individual messages;

the selectively activated distributed processing units are configured to cause the associated electrical contactor to permit charging of the associated electric vehicle responsive to the power distribution manager;

the message generator is configured to generate the individual message for each electric vehicle based at least on a very important person (VIP' priority status of a user of the electric vehicle; and

the message generator is configured to generate the individual message for each electric vehicle based at least on (a) battery characteristics associated with an electric vehicle, (b) time left for charging an electric vehicle, (c) power requested by an electric vehicle, or (d) peak rate/off-peak rate preference of the user of the electric vehicle.

15. A method for providing clustered charge distribution and charge prioritization for electric vehicles, the method comprising:

sensing whether additional power is requested by any one of a plurality of N electric vehicles within a cluster of electric vehicles;

generating, by a message generator, a first EV-specific message, using a first distributed processing unit, for the first electric vehicle based on member information received about the first electric vehicle, wherein the first message is associated with a first power port connected to said first electric vehicle;

generating, by the message generator, a second EV-specific message, using a second distributed processing unit, for the second electric vehicle based on member information received about the second electric vehicle, wherein the second message is associated with a second power port connected to said second electric vehicle;

generating, by the message generator, an Nth EV-specific message, using an Nth distributed processing unit, for the Nth electric vehicle based on member information received about the Nth electric vehicle, wherein the Nth message is associated with an Nth power port connected to said Nth electric vehicle;

transmitting the first message from the first distributed processing unit to a power distribution manager;

transmitting the second message from the second distributed processing unit to the power distribution manager;

transmitting the Nth message from the Nth distributed processing unit to the power distribution manager;

determining, using the power distribution manager, whether power requested by the first, second, and Nth electric vehicles exceeds a location power line limit;

when the power requested does not exceed the location power line limit, activating the first, second, and Nth distributed processing units so that all of the first, second, and Nth electric vehicles receive a charge;

when the power requested exceeds the location power line limit:

comparing the first, second, and Nth messages received by the power distribution manager;

determining a prioritization based on the first, second, and Nth messages; and

selectively activating a subset of the first, second, and Nth distributed processing units based on the prioritization;

after selectively activating the subset of the first, second, and Nth distributed processing units, connecting electrical contactors associated with the selectively activated units;

distributing power from a supply line breaker to the subset of the first, second, and Nth electric vehicles based on the prioritization; and

wherein generating the first, second, and Nth EV-specific messages further comprises generating, by the message generator, the first, second, and Nth EV-specific messages for each of the first, second, and Nth electric vehicles, respectively, based at least on (a) battery characteristics associated with an electric vehicle, (b) time left for charging an electric vehicle, (c) power requested by an electric vehicle, or (d) peak rate/off-peak rate preference of the user of the electric vehicle.

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